TELEPHONE TRAFFIC - MEASUREMENTS

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers and other interested parties with technical information for use in the design and construction of REA borrowers' telephone system. In particular it discusses the means of making traffic measurements in central office equipment in order to secure traffic data to be used as a basis for estimating requirements for a new dial central office or for changes in switch quantities in an existing dial office. It is being reissued to remove superfluous tables and traffic for manual switchboards.

1.2 It is assumed that the reader has familiarized himself with other sections on traffic in this manual and with the more important features of dial switchboards.

1.3 Where there is an existing dial switchboard, traffic measurement data should be secured for expansion or replacement of the board in order that the correct amount of new equipment will be provided. The value of data of this type cannot be overemphasized. Traffic measurements are also necessary for the first addition to a new dial board even if the initial installation was engineered with traffic studies. Extreme subscriber growth could reduce the validity of traffic data, but it is always valuable when dial service has been offered.

1.4 Traffic measurements using one of the switch count methods is a relatively expensive operation and generally should be done only when additions are planned or an existing office is to be replaced. Routine traffic analysis should be done as discussed in the Telephone Operations Manual, Section 1720, "Traffic Studies and Analysis - Dial Offices."

1.5 The objective is to provide sufficient equipment to give the specified grade of service during the average busy hour of the busy season just prior to the next addition.

2. DETERMINATION OF BUSY SEASON BUSY HOUR TRAFFIC

2.1 The busy season is a period when the trunk groups in an office (linefinder, selector, connectors, impulse repeaters, etc.) are busier than at any other period. The busy season could last for a few weeks or, in the case of a resort area, for several months. Generally all of the circuits in the central office will be busier although it is possible for the busy season on certain trunk groups to be different from that of the office as a whole. The busy season in areas associated with an urban economy will generally occur during the winter months, but rural areas may experience a busy season at other times of the year due to marketing activities or other reasons. Traffic measurements should be taken during the busy season, but it is not always practicable to wait. If the ratio of traffic in the busy season to traffic during the period in which the measurements are made is known, it will be satisfactory to adjust the measured data. Usually this ratio must be estimated in which case the following information should be reviewed to increase the reliability of the estimate.

2.11 Traffic Register Data - Peg Count, All Trunks Busy, Last Trunk Busy, and Overflow records will be the most valuable data if taken over a sufficient period of time. The value of this data increases when engineering additions to central offices because the distribution of the grades of service will remain about the same.

4.11 Peg Count - This meter counts the number of calls attempted. Peg count meters may be found on trunk groups other than connectors. When they are furnished, the peg count data for the particular circuit should be used for averaging busy hour traffic study results rather than rely on connector peg count data as suggested in Paragraph 2.

4.12 All Trunks Busy - This meter measures the number of times the last available circuit in the group is seized. In some switchboards there is a timed ATB which measures the length of time an All Trunks Busy condition exists. When this timing exists, it is in six-second intervals.

4.13 Overflow - This meter registers the calls attempted during the time that all the trunks in the group are busy. It measures the effectiveness of the grading employed as well as the adequacy of the number of trunks in the group. Note that on two-way trunk circuits the overflow register in Office A counts only traffic originated in Office A. To determine the total overflow, registrations in A and B must be added.

4.14 Last Trunk Busy - This meter registers the number of times this trunk is busy. It measures the effectiveness of the grading employed as well as the adequacy of the number of trunks in the group.

4.15 Several of these meters are often included in portable traffic measuring equipment. When this equipment is connected properly to central office equipment, the interpretation and analysis of readings is the same as when the meters are an integral part of central office equipment.

4.16 Although not every existing dial office among REA borrowers will be equipped with all the meters listed above, some of the meters have customarily been provided as standard equipment by manufacturers in the past. Therefore, borrowers with existing dial offices may wish to base additional equipment requirements for a given exchange, or exchanges in which similar traffic is anticipated, on measurements obtained from traffic meters in their present equipment. The loading determined entirely by these meter readings is not accurate, but they give a fair indication. In the usual case where an overload is indicated by the meter readings, a switch count should be made to confirm the condition. If an All Trunks Busy, Overflow or Last Trunk Busy meter shows no registrations and the meter circuit is functioning properly, a switch count is in order to determine the amount of excess equipment.

4.17 It is important to realize that except for the peg count register (assuming the average holding time remains constant) the number of registrations is not directly proportional to the traffic offered.

4.2 In addition to the obvious use of traffic registers they have been found useful in highlighting troubles in the switchboard equipment and in the outside plant. If all traffic meters are read and recorded and the readings are compared with the previous readings, an unusual number of registrations may indicate circuit trouble rather than a traffic overload. In small offices readings may be taken each time the office is visited while in large offices it may be desirable to make the comparison weekly or even daily.

4.3 Any time that the meters are read the readi
available for analysis when additions
meters each time the office is visited the f
management an excellent picture of the adequ
from which to make future projections.

5. MEASUREMENTS IN DIAL CENTRAL OFFICES BY

5.1 Some traffic measurements in dial offi
generally used to determine whether th
Switch counts alone are useful to measure th
supplement or confirm data obtained from tra

5.2 At one or two-minute intervals during
observed and the number of switches in
At the end of the observation period the ave
average number of switches in use can then b
by 36 in which case unit call tables in REA
Equipment Switch Quantities," can be used.

5.3 Advantages - No investment in equipment, no setup time, no possibility of inserting troubles, observer may see equipment which is always busy or never busy. Capacity is limited somewhat by type of equipment (switch, relay, etc.) and the number of groups. A switch count can sometimes be made in the time it takes to set up for one of the other methods.

5.4 Disadvantages - Costly in manpower, tiresome, monotonous, usually not practical to get as much data as you would like and more chance of error.

Example 2 - In a group of ten trunks the number of circuits in use are observed during the busy hour and recorded at the end of each minute.

The results are as follows:

TIME	BUSY CIRCUITS IN GROUP (J)	TIME	BUSY CIRCUITS IN GROUP (J)	TIME	BUSY CIRCUITS IN GROUP (J)
10:01	3	10:21	2	10:41	4
02	5	22	2	42	3
03	6	23	3	43	2
04	7	24	5	44	3
05	4	25	7	45	2
06	2	26	5	46	3
07	4	27	5	47	2
08	6	28	4	48	1
09	7	29	3	49	5
10	8	30	3	50	6
11	5	31	3	51	7
12	2	32	2	52	6
13	3	33	3	53	5
14	4	34	2	54	4
15	7	35	4	55	3
16	8	36	6	56	5
17	8	37	8	57	7
18	10	38	7	58	6
19	7	39	7	59	5
20	4	40	5	60	4

What grade of service is being offered?

Solution: Switch count = 279.

$$\text{Number Unit Calls} = \frac{\text{Switch count}}{\text{Number of Observations}} \times 36 = \frac{279}{60} \times 36 = 167.4 \text{ UC}$$

From REA TE & CM-510, "Telephone Traffic - Dial Central Office Equipment Switch Quantities," Figure 2A, it is seen that ten trunks will give a grade of service just over P=02.

5.5 Figures 3 and 4 provide a simple form for recording switch count data. Letters in parentheses are placed on the form to indicate where the various items of information should be recorded. Figure 3A gives the key to the letters on the form in Figure 3. Each letter is shown in reference to a particular item of information. Figure 4 shows an example of a visual switch count recorded on the form shown in Figure 3. Refer to REA TE & CM-510, "Telephone Traffic - Dial Central Office Equipment Switch Quantities." Use Figure 1A or 1B for interpreting the computations for intraoffice trunks and Figure 2A or 2B for interoffice trunks, as applicable.

6. MEASUREMENTS IN DIAL CENTRAL OFFICES WITH AUTOMATIC TRUNK USAGE EQUIPMENT

6.1 A traffic usage recorder is available which scans the individual selectors, connectors, or trunks of a group and records on a meter the number that are in use. The scanning interval may be as short as ten seconds. With a ten-second scan the difference between meter readings at the beginning and end of an hour give tenths of unit calls carried by the group. Recorders now available have enough capacity for measuring usage on all selector and trunk groups found in all but the largest office of any REA borrower. Details for using automatic usage recorders are described in REA TE & CM-516, "Application Guide for a Traffic Study of a Telephone Central Office."

6.2 Advantages - Operates unattended except when readings are to be made. May be equipped to turn off automatically or meters may be read automatically with a movie camera. Each setup can be used for several days' readings. Analysis time is low. Large capacity independent of type of equipment.

6.3 Disadvantages - Investment. Setup time. Possibility of causing trouble during setup. Care required in transporting and maintaining. Requires AC power. Quite heavy to transport.

7. MEASUREMENTS IN DIAL CENTRAL OFFICES USING PEN REGISTERS

7.1 Portable traffic measuring instruments are available which make use of up to 20 pens to indicate on a moving paper tape which of the pens are connected to a busy circuit at any time during the observation period. Such an instrument need not be attended during the observation period; the data will be analyzed at leisure.

7.2 The form of such a recording is shown in Figure 2. The instantaneous busy condition of each circuit is shown by the pips made by a pen associated with each trunk. By making the proper connections to the impulse repeater, selector, connector, revertive call switch, etc., of the group under study, the associated pen will deflect when the circuit is busy.

7.3 A procedure similar to that described in Paragraph 5 may be used to count the number of trunks or switches in use at one or two-minute intervals and to compute the load on the group in unit calls. This example describes the process:

Example 3 - A four trunk group is measured by means of a pen recorder during the busy hour; the results are shown in Figure 2.

a. What is the traffic in unit calls?
b. What grade of service is being rendered?
c. How many trunks would be required to give a grade of service of 0.01?
d. What is the average holding time?

Solution - Dashed lines are shown at 10:00 a.m.; 10:10 a.m.; 10:20 a.m.; 10:30 a.m.; 10:40 a.m.; 10:50 a.m.; and 11:00 a.m. Although an indication of two-minute intervals is shown on the top and bottom edges of the recording tape, the lines connecting them are omitted for clarity. A line joining the top and bottom indications of 10:02 a.m. will show that only Trunk No. 3 is busy at that instant of observation, therefore, 10:02 = 1 trunk. At 10:04 such a line would indicate that Trunks 2, 3, and 4 are busy, therefore, 10:04 = 3 trunks. This process repeated for each two-minute interval up to 11:00 a.m. (30 observations) will yield the following tabulations:

TIME	BUSY TRUNKS	TIME	BUSY TRUNKS
10:02 a.m.	1	10:	
04	3		
06	1		
08	0		
10	0		
12	1		
14	3		
16	1		
18	1		
20	1		
22	2		
24	2		
26	1		
28	1		
30	2		

a. Total Count of Trunks in Use:
Average Number of Trunks in Use (4
Total Usage 1.37 x 3600 (seconds):
Unit Calls 4932 ÷ 100:

b. From REA TE & CM-510, "Telephone Traffic - Dial Central Office Equipment Switch Quantities," Figure 2A, it is seen that a grade of service of P=.05 is being offered.

The number of unit calls could also have been determined by using a map wheel to measure the number of seconds the trunks were busy and dividing the result by 100. This method is probably no more accurate than a sampling of the busy condition at two-minute intervals.

c. For P=0.01 a group of five trunks will carry 46.1 or nearly 49.2 unit calls.

d. The number of calls per trunk is found by adding the number of upward pips:

TRUNK NUMBERS	NUMBER OF PIPS
1	10
2	9
3	10
4	11
	40 calls

The holding time is: $\frac{\text{Total Usage Seconds}}{\text{Total Calls}} = \frac{4932}{40} = 123$ seconds.

Several hundred calls over a number of busy hours would have to be taken if the holding time is being developed for engineering purposes.

7.4 Advantages - Operates almost unattended, can observe load on individual circuits, each setup can be used for several days' readings, may detect equipment which is always busy or never busy, number of attempts and holding times can be determined, capacity independent of type of equipment and the number of groups. Clock spring or AC power models available.

7.5 Disadvantages - Sizable investment, analysis time long, setup time appreciable, possibility of causing trouble during setup, charts and ink require replacement, care required in transporting and maintaining, capacity limited to 20 circuits per instrument.

7.6 Since the pen register records the usage on each individual trunk, it is useful in analyzing grading arrangements when there is reason to believe that the individual legs of a grade are not evenly loaded.

FIGURE 1 - EXAMPLE OF A TRAFFIC STUDY REA-TE & CM-515

TYPE CIRCUIT		Line Finder "400"		Line Finder "500"		Connector "400"			Connector "500"			EAS IN	EAS OUT		TOLL (2W)	
NO. OF CIRCUITS		13		13		13			13			4	4		9	
TYPE METER		OVER FLOWS	UNIT CALLS	OVER FLOWS	UNIT CALLS	PEG COUNT	OVER FLOWS	UNIT CALLS	PEG COUNT	OVER FLOWS	UNIT CALLS	UNIT CALLS	OVER FLOWS	UNIT CALLS	OVER FLOWS	UNIT CALLS
	Hour Date															
Busy Season Traffic Meter Registrations	9 AM 8/15 9 AM 8/22	11		14		5227	9		6960	5			289		10	
	9 AM 8/22 9 AM 8/29	55		9		8887	4		7213	7			309		18	
	9 AM 8/29 9 AM 9/5	18		13		7639	8		7835	6			300		14	
	9 AM 9/5 9 AM 9/12	141*		11		7482	13		6889	5			439**		0	
Traffic Meter Registrations On Switch Count Days	9 AM 8/22 9 AM 8/23	36		0		1182	1		1211	1			1		8	
	9 AM 8/23 9 AM 8/24	8		2		1073	2		1036	3			52		0	
	9 AM 8/24 9 AM 8/25	3		2		1106	0		969	0			7		1	
	9 AM 8/25 9 AM 8/26	1		1		1158	1		972	0			4		0	
Busy Hour Measurements On Switch Count Days	Mon 8/22	13	267	0	220	122	0	208	131	0	219	64	0	63	8	180
	Tues 8/23	2	204	1	230	102	1	187	116	1	205	87	12	108	0	163
	Wed 8/24	1	197	1	227	108	0	193	102	0	201	71	1	81	1	159
	Thurs 8/25	1	213	1	216	113	1	178	97	0	197	81	2	89	0	157
	Fri 8/26	0	194	0	189	117	0	192	102	0	213	74	1	76	1	168
Five day total B.H.U.C.			1075		1082			958			1035	377		417		827
Five day average B.H.U.C.			215		216			191			207	75		83		165
Estimate for Engineering 95% of average B.H.U.C.***			205		205			181			196	71		78		157
Grade of service objective			.02		.02			.02			.02	.05		.05		.03
Number of circuits required			12		12			11			11	5		6		9
Engineered grade of service			.02		.02			.02			.03	.05		.03		.04

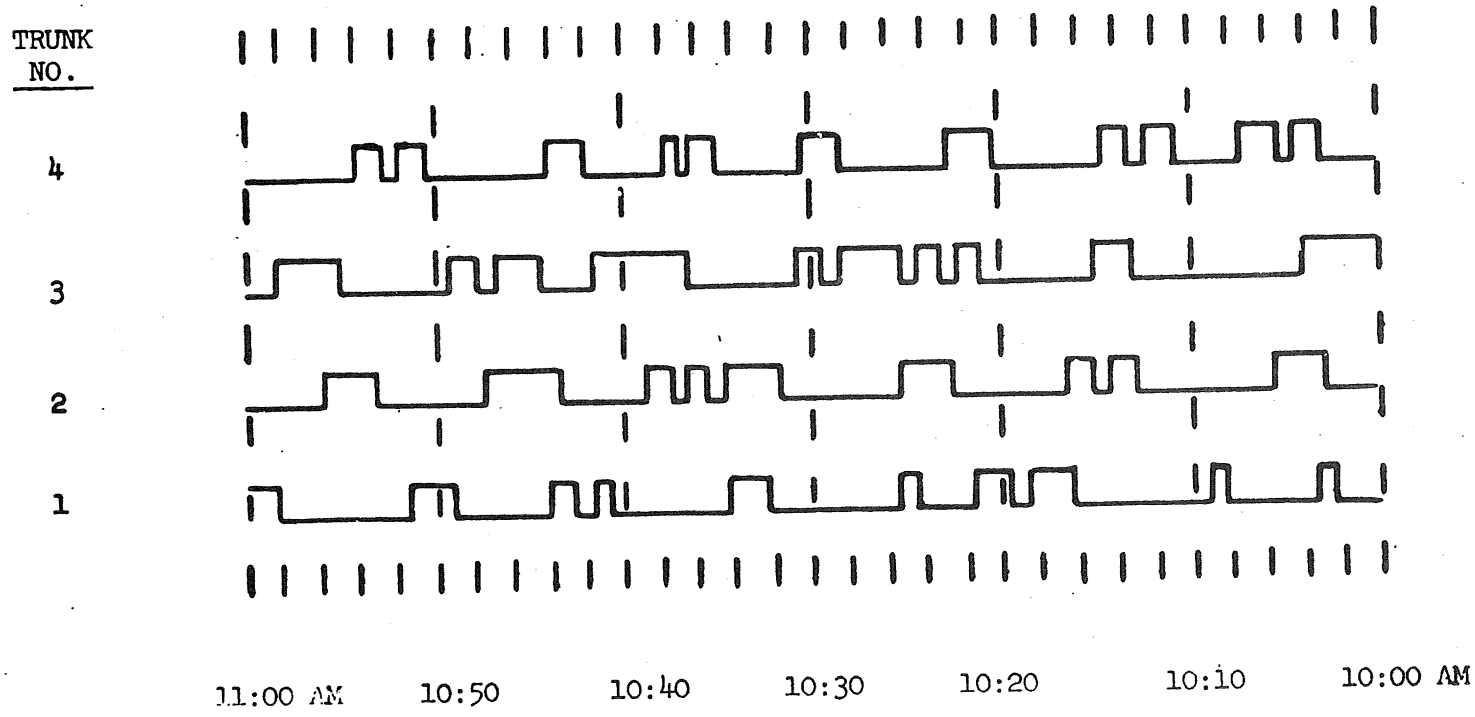
* 69 one day - 67 second day

** 211 registrations one day

*** All traffic is estimated to be proportional to connector peg count and the average of the three highest weeks is to be used for engineering purposes.

$$\frac{1/3(8887/7639/7482/7213/7835/6889)}{8887 / 7213} = .95$$

FIGURE 2 - EXAMPLE OF PEN REGISTER RECORDINGS



(Pips Indicate Busy Circuits)

CENTRAL OFFICE VISUAL SWITCH COUNT DATA

EXCHANGE (A) DATE (B)

BUSY HOUR (C) SHEET NO. OF (D)

TYPE SWITCH GROUP	(E)									
GROUP NUMBER	(F).									
LOCATION	(G)									
NUMBER OF SWITCHES	(H)									
TRAFFIC REGISTER ATB, LTB, PC, ETC.	(I)									
TRAFFIC REG. READ - START	(J)									

TIME	REMARKS	RECORD NUMBER OF BUSY SWITCHES EVERY TWO MINUTES OF BUSY HOUR								
(K) :00										
:02		(L)								
:04										
:06										
:08										
:10										
:12										
:14										
:16										
:18										
:20										
:22										
:24										
:26										
:28										
:30										
:32										
:34										
:36										
:38										
:40										
:42										
:44										
:46										
:48										
:50										
:52										
:54										
:56										
:58										
:60										

TOTAL SWITCH COUNT	(M)									
TOTAL OBSERVATIONS	(N)									
TRAFFIC REG. READ STOP	(O)									
DIFFERENCE START-STOP	(P)									
UNIT CALLS										

REMARKS: Unit Calls (UC) = $\frac{M \times 36}{N}$

Holding Time = $\frac{UC}{P \text{ (Peg Count Register)}} \times 100$

FIGURE 3 - CENTRAL OFFICE VISUAL SWITCH COUNT DATA

KEY TO LETTERS ON FIGURE 3

(A) - Record exchange name.

(B) - Record date switch count is taken.

(C) - Record "busy hour" studied, such as 9:00 A. M. to 10:00 A. M.

(D) - Fill in number of sheets.

(E) - Indicate type of switch group studied, such as: Linefinders, Connectors, Second Selectors, Toll Trunks, etc.

(F) - Record group number such as: 2,000, 3,000, etc.

(G) - Record position of switch group, if applicable.

(H) - Record number of switches in group studied.

(I) - Record type of traffic register installed in group.

(J) - Record traffic register readings for each group at the start of "busy hour," such as: 9:00 A.M.

(K) - Indicate begin "busy hour" here, such as: 9:00 A. M.

(L) - Record number of switches busy in these columns for all groups studied every two minutes of "busy hour."

(M) - Add column. Total switch count.

(N) - Record total observations which is 30 if Column L is recorded every two minutes of "busy hour."

(O) - Record traffic register readings for each group at the end of the Busy Hour, such as: 10:00 A.M.

(P) - Subtract Column J from O.

FIGURE 3a

CENTRAL OFFICE VISUAL SWITCH COUNT DATA

EXCHANGE Anytown — DATE March 3, 1964

BUSY HOUR 9:00 - 10:00 A.M. — SHEET NO. 1 OF 1

TYPE SWITCH GROUP		Conn.	Conn.	Conn.	Conn.		Toll			
GROUP NUMBER		2100	2200	2300	2400		"0"			
LOCATION										
NUMBER OF SWITCHES		9	7	7	7		6			
TRAFFIC REGISTER ATB, LTB, PC, ETC.		PC	PC	PC	PC		ATB			
TRAFFIC REG. READ. - START		3462	2957	3071	3121		1072			
TIME	REMARKS	RECORD NUMBER OF BUSY SWITCHES EVERY TWO MINUTES OF BUSY HOUR								
9:00										
:02		3	2	2	3		3			
:04		6	5	4	3		2			
:06		2	2	1	1		2			
:08		4	3	2	2		3			
:10		4	3	2	2		1			
:12		5	4	3	2		2			
:14		3	3	3	3		2			
:16		8	6	5	5		1			
:18		2	2	1	2		1			
:20		3	2	2	1		2			
:22		3	2	1	1		1			
:24		2	1	1	1		2			
:26		8	5	3	2		2			
:28		3	3	3	3		2			
:30		5	3	2	2		1			
:32		4	3	3	3		1			
:34		5	4	3	2		2			
:36		3	3	2	2		1			
:38		6	4	3	3		2			
:40		3	3	3	3		3			
:42		6	5	4	3		1			
:44		3	1	2	2		1			
:46		5	3	2	3		2			
:48		3	2	2	2		1			
:50		5	3	3	2		2			
:52		5	3	2	2		2			
:54		6	5	4	3		3			
:56		3	3	2	2		2			
:58		5	3	2	2		1			
:60		5	4	4	3		2			
TOTAL SWITCH COUNT		128	95	76	70		53			
TOTAL OBSERVATIONS		30	30	30	30		30			
TRAFFIC REG. READ. STOP		3542	3049	3141	3201		1072			
DIFFERENCE START-STOP		80	92	70	80		0			
UNIT CALLS		153	114	91	84		64			

REMARKS: All trunk groups are off first selector levels and appear to be giving adequate service, except the 2200 connector group, which may require 8 switches. Further busy hour observations will determine this more precisely.

FIGURE 4